FORESTRY COMMISSION
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Forestry Expansion – a study of technical, economic and ecological factors

UK Demand for and Supply of Wood and Wood Products

A. Whiteman
Economist, Forestry Commission

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INTRODUCTION

The last thorough study of UK supply and demand for wood was the *Wood Production Outlook in Britain*, (Forestry Commission, 1977). Other recent international studies have examined the UK situation in an abbreviated form, notably those done by the Economic Commission for Europe (United Nations, 1986) and the International Institute for Applied Systems Analysis (Kallio *et al.*, 1987), but these have often been constrained to using models that also suit a wide range of other countries. A new study is therefore timely. This paper examines the UK market for wood,* describes the models of supply and demand that have been built by the Forestry Commission, then makes projections based on those models to 2050. For a more detailed exposition of the supply and demand models presented here, the reader should consult Whiteman (1991).

THE MARKET FOR WOOD

Wood has always played an important role in human activities. The use of wood as fuel is crucial in many parts of the world, while in the UK, wood is needed for many industrial and domestic purposes. Current UK consumption of wood currently stands at about one cubic metre per person per year. Some products (such as fuelwood or fence posts) are easily converted from standing tree to product, while others have to go through several complicated industrial processes (for example, wooden furniture and fine writing

*The term wood refers to wood and wood products, including sawnwood, panel products and paper products.

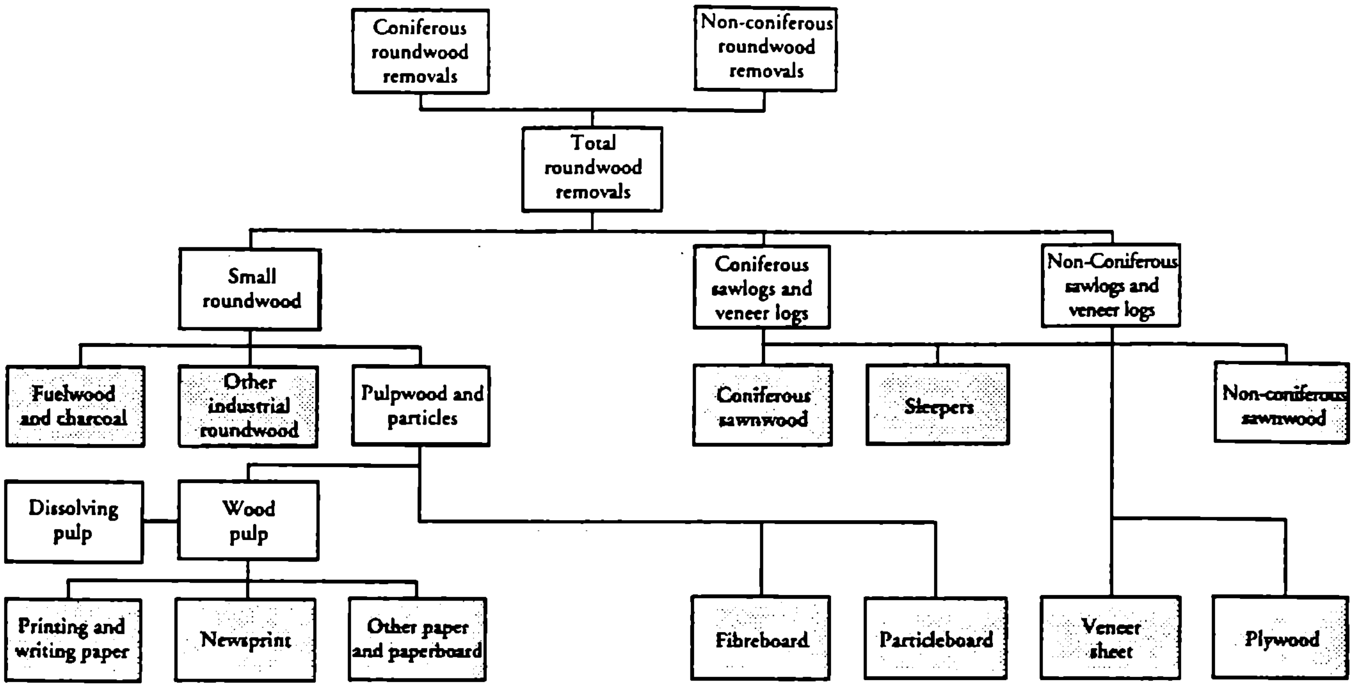
paper). These complicated processing chains create a large market for intermediate products. Also, some wood products are consumed directly while others are part of a manufacturing process. Different products should therefore, be analysed in different ways, for example, sawnwood and panel products, which mainly go into the construction industry (see Table 1), can be related to the demand for that industry's services and hence its level of output, but the demand for writing paper comes straight from consumers, and can be analysed as such.

Table 1 Main end-use sectors of mechanical wood products

Percentage by volume	*Sawn and planed softwood*	*Sawn hardwood*	*Plywood and blockboard*	*Wood particleboard*
Constructions	67	38	48	49
Furniture	4	24	16	40
Transport	0	4	11	3
Packaging/pallets	14	9	10	1
DIY	3	0	6	5
Others	1	15	9	2
Fencing	11	10	-	-
	100	100	100	100
Approximate consumption million m^3 true volume (1980)	8.5	1.4	1.0	1.0

Sources: Cibula (1980) and Elliott (1985) with percentages updated to the present from Forestry Commission sources.

Eleven main categories of wood product are identified by the Food and Agriculture Organization of the United Nations. The relationship between these products and the intermediate products and raw materials that go into making them is shown in Figure 1. Converting timber into one of these products often involves a loss of material. For example, in the manufacture of sawnwood, bark is removed and some of the wood from the larger diameter at the bottom of the tree cannot be sawn. Such residues are often used elsewhere as fuel or chips for pulping and, in the case of bark, there is strong demand for this product in its own right. The conversion factors from standing roundwood volume to product volume (or weight, in the case of paper products), are presented below in Table 2. These were used in the study to convert demand for products back into demand for roundwood. With demand expressed as a roundwood equivalent (called wood raw material equivalent or WRME), the balance between UK supply and demand for wood could be calculated.



Notes: Shaded boxes represent final products. Recycling/residue interactions are not shown.

Figure 1 The linkages between roundwood and wood products

Table 2 Conversion factors – volume of roundwood (in m^3) required to get one unit of product (one metric tonne of paper otherwise one cubic metre of product)

Plywood	2.30	Newsprint	2.80
Veneer sheets	2.00	Printing and writing paper	3.50
Fibreboard	2.26	Other paper and paperboard	2.50
Particleboard	1.37		
Fuelwood and charcoal	1.00	Non-coniferous sawnwood	1.72
Other industrial roundwood	1.00	Coniferous sawnwood	1.75

Sources: United Nations (1987), Forestry Commission

On the supply side, Table 3 shows how insignificant domestic wood supply is compared with wood demand. Seventy per cent of coniferous sawnwood comes from Finland, Sweden, Canada and the USSR, as does 36% of the wood pulp to make paper and 25% of the paper itself. These products account for a large part of UK wood consumption, so it can be seen that the UK depends for most of its supplies of wood on just four countries. The smaller market for non-coniferous wood is in a similar position, with 39% of the sawnwood, and 45% of plywood consumption being supplied by just four countries with extensive tropical forests. The history of UK supply and demand is shown in Figure 2. Wood demand has grown, but domestic supply has not been able to increase to meet this demand. This has resulted in increasing imports, so that now, the UK produces only 12% of its wood requirements (Forestry Commission, 1989a).

Table 3 Countries supplying the UK market for wood (figures are percentages of domestic consumption by quantity in 1988)

Countries	*Coniferous sawnwood*	*Non-coniferous sawnwood*	*Plywood*	*Particleboard*	*Fibreboard*	*Wood pulp*	*Paper and paperboard*
United Kingdom	16	22	1	35	33	16	46
Temperate forests							
Canada	28	4	11	-	3	15	2
USSR	12	-	6	-	2	-	-
Sweden	19	-	-	2	14	12	10
Finland	11	-	4	6	5	9	13
USA	2	18	9	-	12	10	2
Tropical forests							
Brazil	-	8	6	-	1	1	1
Philippines	-	16	6	-	-	-	-
Malaysia	-	5	4	-	-	-	-
Indonesia	-	9	15	-	-	-	-
Others	12	18	38	57*	29	37	26
	100	100	100	100	100	100	100

*Mainly from within the EEC
Source: United Nations (1986)

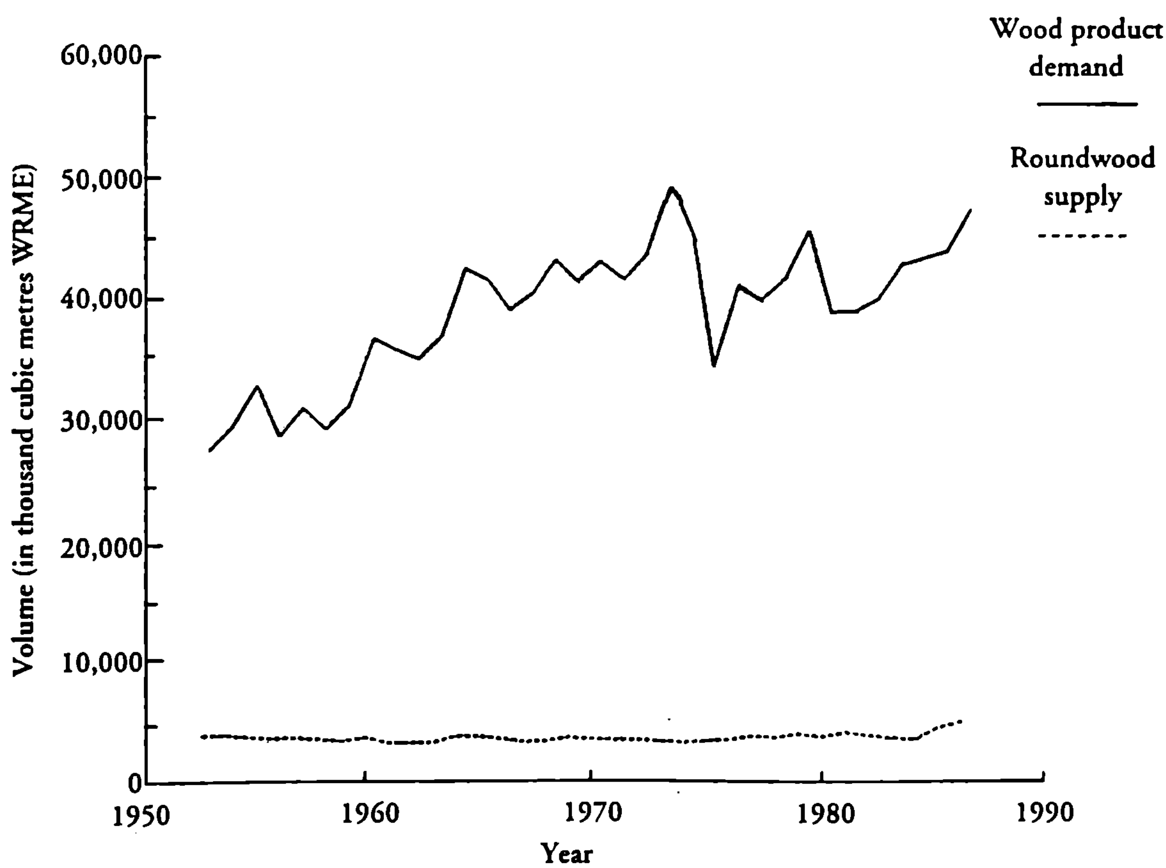


Figure 2 United Kingdom roundwood supply and wood product consumption 1953-1986 (expressed as wood raw material equivalent)

Research into supply and demand carried out by the Forestry Commission focused on two approaches. Firstly, supply was analysed along the lines of a systems analysis approach. Secondly, demand was analysed using econometeric techniques. Because domestic supply satisfies only a small amount of domestic demand, and is even more insignificant on a world scale, it cannot affect demand through the price mechanism. This meant that supply and demand could be modelled separately.

It was not necessary to study past supply in any great detail. Research results already indicate the growth and output patterns of typical tree stands (Edwards and Christie, 1981) and a system is already in place that enables rotation ages and hence yield to be adjusted in areas that are susceptible to wind damage (Miller, 1985; Forestry Commission, 1989b). To convert from these essentially microeconomic studies to aggregate output, the age-structure and size of the existing crop must be known, and this was also provided by the last census of woodlands (Locke, 1987) supplemented with more recent information from Forestry Commission sources. The only factor likely to affect supply about which there was uncertainty, was price. It was not possible to disentangle the effect, if any, of historical price on historical supply, so the assumption was made that price has no effect on supply (i.e. a vertical supply curve).

Demand was analysed in much more detail. Motels were built to explain demand in the following 11 product categories over the period 1956-86:

- fuelwood and charcoal
- other industrial roundwood
- coniferous sawnwood
- non-coniferous sawnwood
- printing and writing paper
- newsprint
- other paper and paperboard
- fibreboard
- particleboard
- veneer sheets
- plywood

Data for the models was obtained from United Nations (1988) sources.
A range of independent variables were examined as suitable explanatory variables in the demand equations. These included:

- microeconomic variables (e.g. population, gross domestic product)
- industry variables (e.g. construction output, coal production)
- own price (including lagged own price)
- substitute prices (e.g. price of concrete, price of alternative wood products)

The specification of the equations was important. In econometric studies, simple or log-linear equations are usually found to have the best combination of economic and statistical properties, and this was also the case here. These two specifications were applied to models of both aggregate and per capita consumption, and the best results from each of the four models was chosen. Semi-logarithmic specifications were also tried, but found not to be as good. Most of the models assumed full and instantaneous adjustment. A summary of the final chosen models is given in Table 4. A fuller discussion of the supply and demand mechanism, and the statistical techniques used to model these variables is contained in Whiteman (1990).

Table 4 Summary of demand models for wood products in the UK

Wood product	*Significant explanatory variables*	*Price elasticity*	**Corrected for autocorrelation*	R^2
Fuelwood and charcoal	Lagged consumption	–	yes	NA
Other industrial roundwood	Colliery output Concrete price Miners' strike 1984/5	–	yes	85
Coniferous sawnwood	Lagged price Construction output Wood based panels price Concrete price Non-coniferous sawnwood price	- 0.582	no	NA
Non-coniferous sawnwood	Price Construction output Wood based panels price Concrete price	- 0.370	no	NA
Printing and writing paper	Income	–	yes	44
Newsprint	Price Income	- 0.316	no	38
Other paper and paperboard	Income	–	yes	73
Plywood	Price Construction output Non-coniferous sawnwood price	- 0.761	no	NA
Fibreboard	Price Investment	- 0.908	yes	NA
Veneer sheet	Construction output Non-coniferous sawnwood price	–	yes	NA
Particleboard	Price Investment	- 0.475	yes	NA

*Corrections for autocorrelation were carried out using the Cochrane-Orcutt iterative technique for estimating Rho, the autocorrelation coefficient. This was only done in cases where the Durbin-Watson test statistic indicated the presence of serious autocorrelation.

The forecasts of future supply and demand are presented in Figure 3. These were derived from the models outlined in the previous section. Two future scenarios were examined, and these are described below.

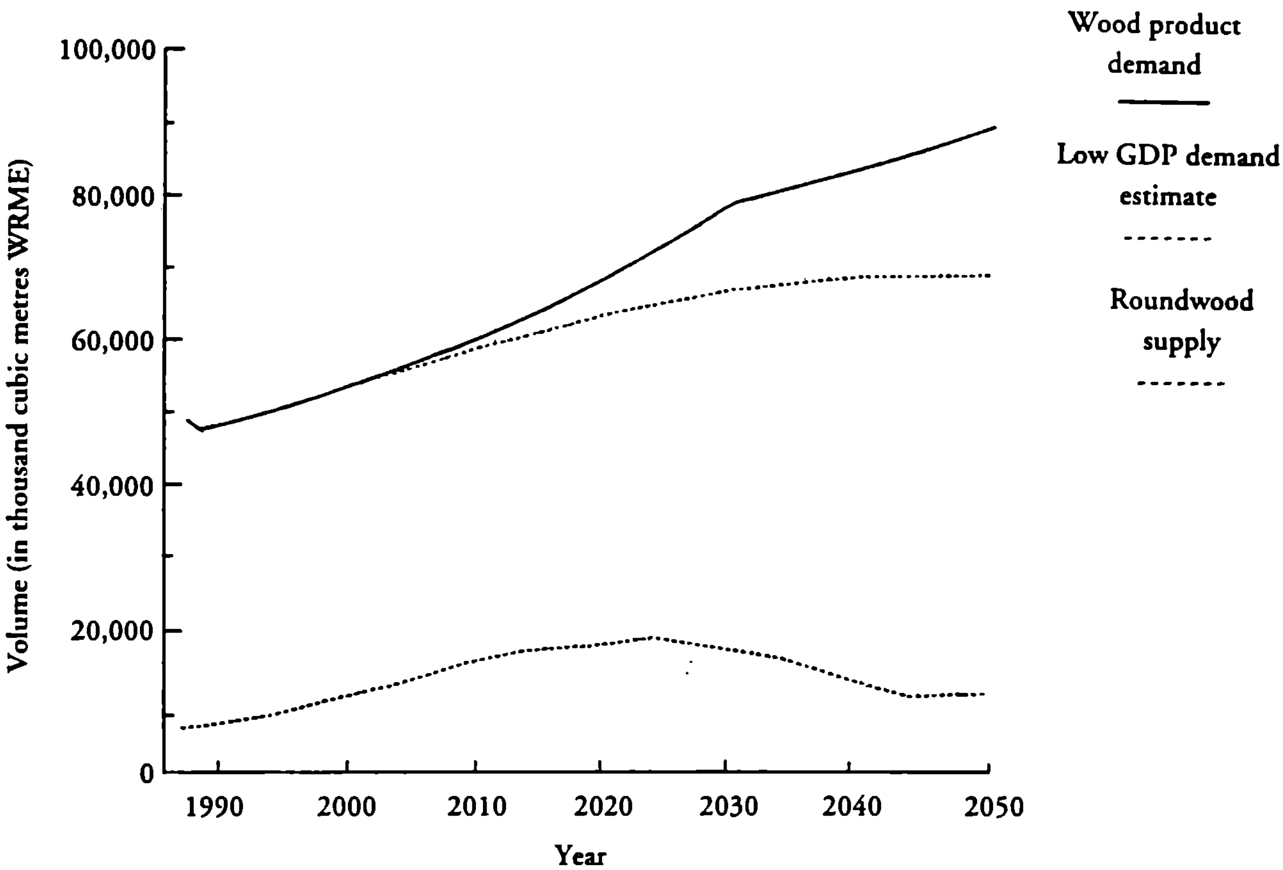


Figure 3 Forecast of United Kingdom roundwood supply and wood product demand 1987-2050 (expressed as wood raw material equivalent)

On the supply side, future output was protected using typical production forecasting techniques (Johnston *et al.*, 1967; Johnston, 1973; Dewar, 1988; Kupiek and Phillip, 1988). Given the current crop area, age-structure and species composition, yield models were used to forecast future volumes from the existing estate, assuming rotation ages based on some notion of economic optimality (Insley *et al.*, 1987). This was further modified to take into account production and environmental constraints, such as long-term supply contracts to large timber processors and restrictive top heights for crops because of likely wind damage. This process was much easier and is likely to be a more accurate reflection of production from the proportion of the estate in Forestry Commission hands than that owned by the private-sector. This is because of deficiencies in the data collected about the private sector.

The forecast of future wood supply is shown in greater detail in Table 5, and Figure 4. The difference between this and previous production forecasts (e.g. Forestry and British Timber, 1987) is that it runs over a much longer period, and takes into account the volume to be harvested from second rotations. To do this, it was assumed that timber yield from each timber stand would be exactly the same as in the first rotation.

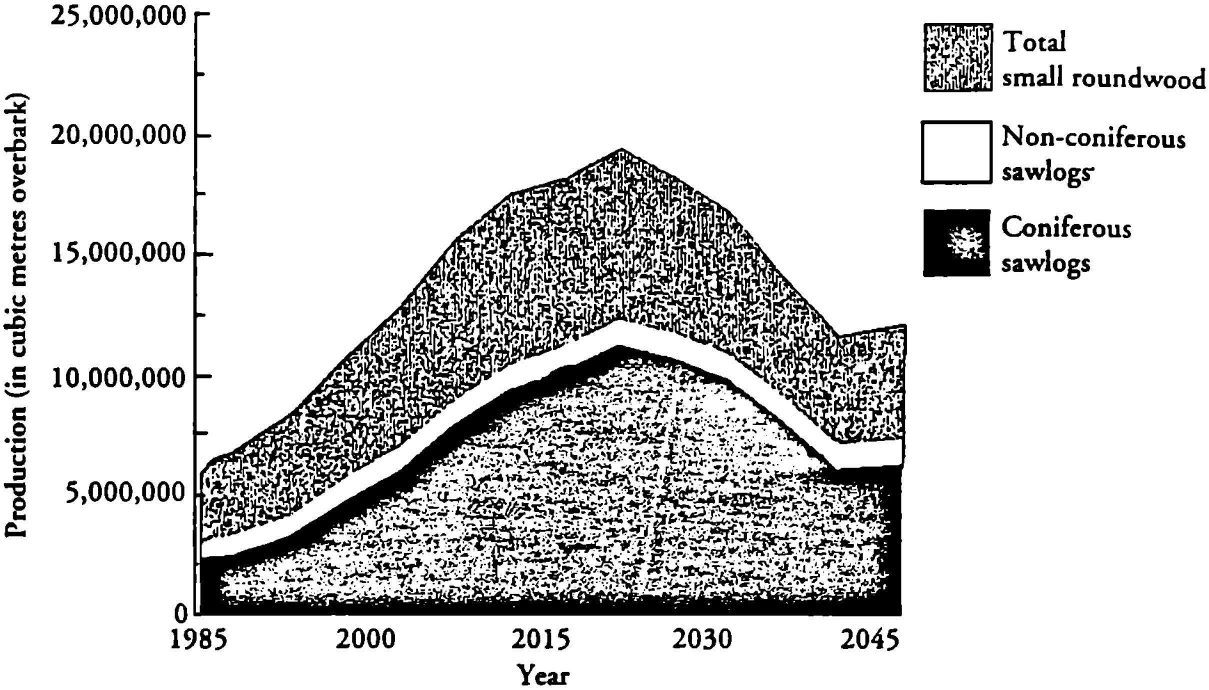


Figure 4 Forecast of United Kingdom roundwood production to 2050

Table 5 Total United Kingdom forecast of annual production to 2050

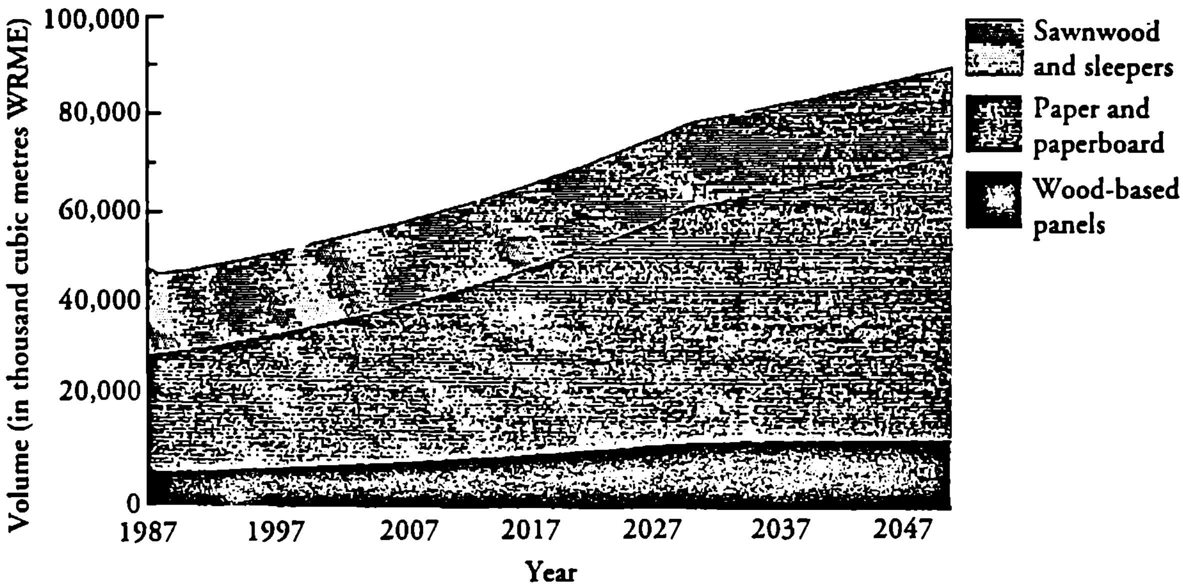
Period	*Coniferous sawlogs*	*Coniferous small roundwood*	*Non-coniferous sawlogs*	*Non-coniferous small roundwood*	*Total*
1987-1991	2.6	3.2	0.9	0.2	6.9
1992-1996	3.4	4.0	0.9	0.2	8.5
1997-2001	4.8	4.8	1.0	0.1	10.8
2002-2006	6.1	5.7	1.0	0.1	13.0
2007-2011	8.1	6.5	1.0	0.1	15.8
2012-2016	9.6	6.9	1.0	0.1	17.7
2017-2021	10.4	6.8	1.1	0.1	18.4
2022-2026	11.5	6.9	1.1	0.1	19.6
2027-2031	11.0	6.3	1.1	0.1	18.4
2032-2036	10.2	5.7	1.1	0.1	17.1
2037-2041	8.4	4.7	1.1	0.1	14.3
2042-2046	6.5	4.4	1.1	0.1	12.0
2047-2050	6.6	4.6	1.1	0.1	12.4

All figures expressed in million cubic metres overbark.

Two demand projections were made assuming different rates of growth in national income or GDP. An initial assumption was that GDP would grow in real terms by 2½% per year. This is based on historical evidence. A second hypothesis was also presented, showing a slowdown in GDP growth until it reached zero in 2040. Many of the explanatory variables were assumed to be related to GDP and were projected forwards as such. A population projection was taken from the Central Statistical Office (1988), and other remaining variables were projected on the basis of past trends. Constant prices were assumed for the future, and in the forecasts they were set to their average level over the past 10 years.

The forecast of wood demand or consumption to 2050 is presented below in Table 6 and Figure 5. Also presented in the table are the estimated actual figures for 1989. It is noticeable that for the higher GDP growth forecast, the demand forecast shows lower growth after 2030. This is because some of the demand models for paper and panel products had to be restricted to a ceiling on consumption per head, because of high income elasticities in the model that led to excessive predictions of demand. These ceilings were determined by examining consumption per head in a selection of countries with well developed forest sectors, and tended to take effect around 2030.

a.



b.

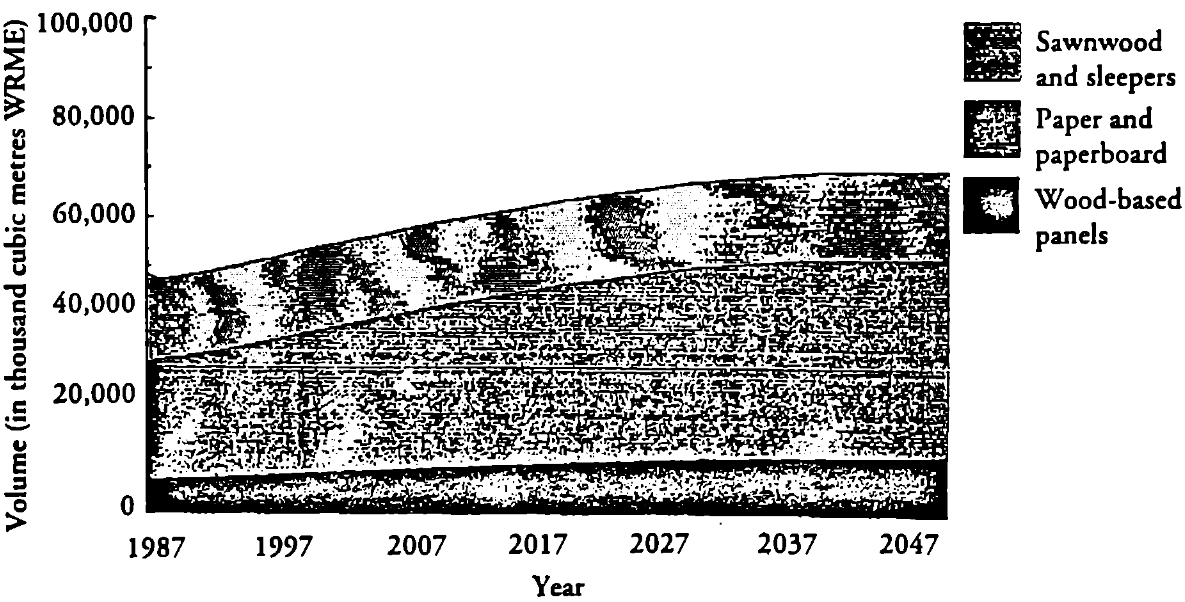


Figure 5 The demand for the major wood product groups over the period 1987-2050 (expressed as wood raw material equivalent)

a. High GDP growth scenario
b. Low GDP growth scenario

Table 6 Forecast demand for wood in the UK to 2050 (expressed in million cubic metres WRME)

	Actual	*GDP*	*Year*			
	1989	*growth rate*	*2000*	*2010*	*2025*	*2050*
Wood-based panels	6.6	H	8.3	9.8	12.6	14.3
		L	8.3	9.4	10.8	11.6
Paper and paperboard	20.8	H	28.4	33.5	43.8	58.1
		L	28.4	32.4	37.3	40.3
Sawnwood	18.8		16.8	17.0	17.2	17.7
Other roundwood	0.4		0.5	0.4	0.4	0.3
Total	46.4	H	54.1	60.8	74.2	90.5
		L	54.1	59.4	65.9	70.1

DISCUSSION OF THE MODEL AND FORECASTS

The demand models are essentially designed to account for short-run variations in the variables of interest; when it comes to evaluating long-run stable solutions to demand equations, the techniques used to construct these models may not be very reliable. This is further exacerbated when forecasts are required for the next 60 years, and there are only 30 years of data. Leaving aside the problem of exogeneity of the independent variables (Engle *et al.*, 1983), the process of forecasting also requires that assumptions are made about the future path of the underlying explanatory variables. Putting all these factors together, it does indicate that the accuracy of these long-term forecasts is questionable, although the general trends they show may be about right.

In the supply projection, it was assumed that future production would be determined by profit maximisation motives. This may not necessarily be the case. Traditional estates in the private sector manage their woods for a range of motives. This probably accounts for the fact that the hardwood harvest is only about half the potential each year (Oakley, 1986). However, with the emergence of large investment plantations, supported by generous tax consessions over the last two decades, it is possible that future production will be managed more with profit in mind. This will tend to support the forecast for coniferous timber, because most of the investment plantations are planted with conifers. Even so, these forecasts may be wrong, because incorrect assumptions have been made about rotation lengths. For example, plantation owners have been known to clear fell prematurely when the price for small roundwood is high. This is quite rational, and will affect the accuracy of the forecast.

For the Forestry Commission side of the forecast, there are also uncertainties. The motive of profit maximisation is likely to change in the future as the wider social and environmental costs and benefits of forestry begin to be appreciated. This may result in changes in production that will be much greater than those now caused by-improvements in forest design. Changes in the discount rate required for public sector investment appraisal may alter optimal rotation ages, and alternative production strategies to meet timber processors' needs may also alter the pattern of future harvests. This forecast has assumed the simplest of policy prescriptions, that of the profit maximiser. This is more likely to change in the public sector than the private sector.

On the technical side, other factors have an influence. Improvements in silvicultural techniques may lead to increased yield in the future from both current and subsequent rotations. However, set against this, future improvements in landscape design and forest conservation will mean more land will be left unplanted and small areas of forest may become unproductive. Without any detailed insight into what may happen, it has been assumed that these two effects will roughly compensate for one another.

One of the more contentious assumptions on the demand side is that it may be the case that the deforestation of tropical forests will cause hardwood prices to rise relative to softwoods in the future.

Also, on closer examination, it can be seen that a large part of the growth in UK timber prices occurred during the Second World War. Detailed time-series analysis has shown that since the Second World War, there has been neither upward or downward pressure on real timber prices. This view is also taken by the UK Treasury (HM Treasury, 1972) and the National Audit Office (1986).

Another issue on the demand side is the correct specification of the models. Full and instantaneous adjustment was assumed, which implies perfectly functioning timber markets. Other research supports the view that lags and partial adjustment may be a more accurate reflection of the dynamics of the timber market. (Buongiorno, 1990, provides a good review of different model specifications that have been applied to forest products markets). The models do appear to result in quite high levels of R^2 or goodness-of-fit, but it would be interesting to test more complicated specifications.

In calculating the raw material balance (Figure 3) the conversion factors from Table 2 were used to convert product demand into roundwood equivalent. This will probably overstate future roundwood requirements. Firstly, future technological change is likely to increase the amount of product that can be obtained from each cubic metre of roundwood. Secondly, the use of residues and recycled material will almost certainly increase in the future. This will increase the apparent conversion from roundwood to product, as more of the product is recycled and reused. Currently, 3 million m^3 of sawlogs are available to sawmills in the UK. It is likely that sawmilling capacity will increase in line with the production of sawlogs, then fall off until 2045 after which it will be set to increase again to process the logs from clear felling from the next rotation. This means that total UK employment in sawmilling could potentially rise from the 6000 recorded in 1987 to about 25000 in 2025 then fall to 15,000 in the 2040s. However, improvements in labour productivity in the sawmilling sector may result in employment increasing only marginally to, say, about 12000 in 2025, after which it could fall back to current levels in 2050.

Total timber processing currently employs about 10000 people in Great Britain (Thompson, 1990), so the remaining 4000 work in pulp, paper and board mills (plus a few involved in minor activities such as firewood, round mining timber and other small specialised processing). The peak in production shown in Figure 4 is less dramatic for small roundwood than for sawlogs. Production more than doubles and this is likely to result in a doubling of processing for a short while. However, employment is not likely to increase greatly.

Expanding roundwood production until the year 2000 can be accommodated by existing processing capacity, with perhaps a little roundwood being exported. By 2000, there should be sufficiently good prospects to attract new capacity, increasing the small roundwood processing sector by about 50%. The doubling of capacity will not come until about 2010, and will last until about 2035, at which time contraction in the supply of small roundwood will result in removal of some of that capacity. The initial increase of 50% in capacity should be sustainable, however, given this production forecast. The sluggishness of processing capacity to respond to roundwood supply in the paper and board sector is due to the long-term nature of investment in the industry. A paper mill is expected to operate for 15 years or more to be profitable whereas a sawmill can pay back the initial investment in only five.

Productivity improvements are likely to be greater for processing small roundwood than for sawmilling, and the increasing size of production units is likely to improve economies of scale and further reduce the required labour input to process each extra cubic metre of roundwood supplied. Because of this it is likely that the capacity increase in 2010 will only result in 1000-2000 new jobs, with maybe a further 1000 jobs in the extra capacity 2010-35.

If an attempt was made to smooth production of roundwood, this would involve significant holding costs to transfer excess supply from the period 2010-35 to fill the trough from 2036 onwards. This would be a one-off cost however, because the simultaneous postponement of restocking would ensure stable supplies in the future. The sustainable annual level of timber supply from existing forest area is about 16 million m^3 per year, 6 million m^3 small roundwood and 10 million m^3 sawlogs, and would be reached in 2010.

The cost of such a restructuring of felling plans is difficult to estimate because of uncertainties about forecast volumes and prices. The forecast indicates that about 1.2 billion cubic-metre-years of timber would have to be delayed (one cubic-metre-year meaning to delay felling of one cubic-metre for one year). This would mean that on average, over the period 2010-56, 26 million m^3 of standing timber would be past its economically optimal felling age. This figure would really be much lower at the beginning and end of the period, but peak at about 50 million m^3 in 2035 (see Figure 6).

At current prices, this whole operation would cost about £388 million (discounted at 6% to 2010) in delayed production. Discounted back to 1990, this cost has a present value of only £121 million. This cost could be much reduced however, by incorporating the smoothing exercise in future landscaping and conservation plans.

An alternative way to smooth out production is of course, to plant now to sustain production at the peak. This would be difficult because the peak, in about 2025, is only 35 years away. Rotations of such a short length are only optimal on very productive land and thinnings could not produce enough volume to stop the downturn. However this problem could be overcome by a slight rescheduling of production at a modest cost. To increase production from its currently sustainable annual level of 16 million m^3 to the peak of 20 million m^3 requires an additional annual harvest of 4 million m^3. A typical yield model for average new planting* would give a yield of about 500 m^3 in thinnings and clear felling volume over a rotation of 50 years (10 m^3 $year^{-1}$). To sustain production therefore would require new planting of approximately 400 000 ha in total (400 000 x 10 m^3 $year^{-1}$ = 4 million m^3 $year^{-1}$). This would have to be weighted towards the near future because of the shape of the peak, and the problem of the timescale mentioned above. Such a planting programme is shown in Figure 7. At a subsidy of about £1000/ha to new planting, this would cost £243 million over a period of 30 years. The cost of such a programme would be about twice the cost of rescheduling production and would involve quite a large change in land-use. It would, however, have the benefit of sustainably increasing processing and employment in the UK forest sector to a level about 25% above its currently sustainable level.

It is doubtful whether the cost of either of these two options could ever be justified on these grounds alone. The cost per job of increasing production is high, and the benefits of smoothing production are unknown if indeed there are any benefits at all. However, added to the other multiple benefits of forestry, this may tip the balance in favour of some new planting, but is likely to be insignificant compared with the other benefits that forestry can offer.

CONCLUSION

This paper has shown that future demand for wood in the UK is likely to be very strong. This demand cannot be satisfied from domestic supply sources, and the UK is likely to be relying more in the future on imported wood. If the real price of wood increases, then the raw material balance will change, because demand will fall. This is not likely to happen, however, in the foreseeable future. The changing pattern of future wood production will have major implications for the wood processing industry. The most likely scenario is that, without further modification, the industry will expand with production to 2025, then contract until 2040, when production will increase from the next rotation. Various measures could be taken to counteract this cycle, but they are expensive.

*Sitka spruce, yield class 14, 2 m x 2 m spacing, line MTT thinning, 85% stocking.

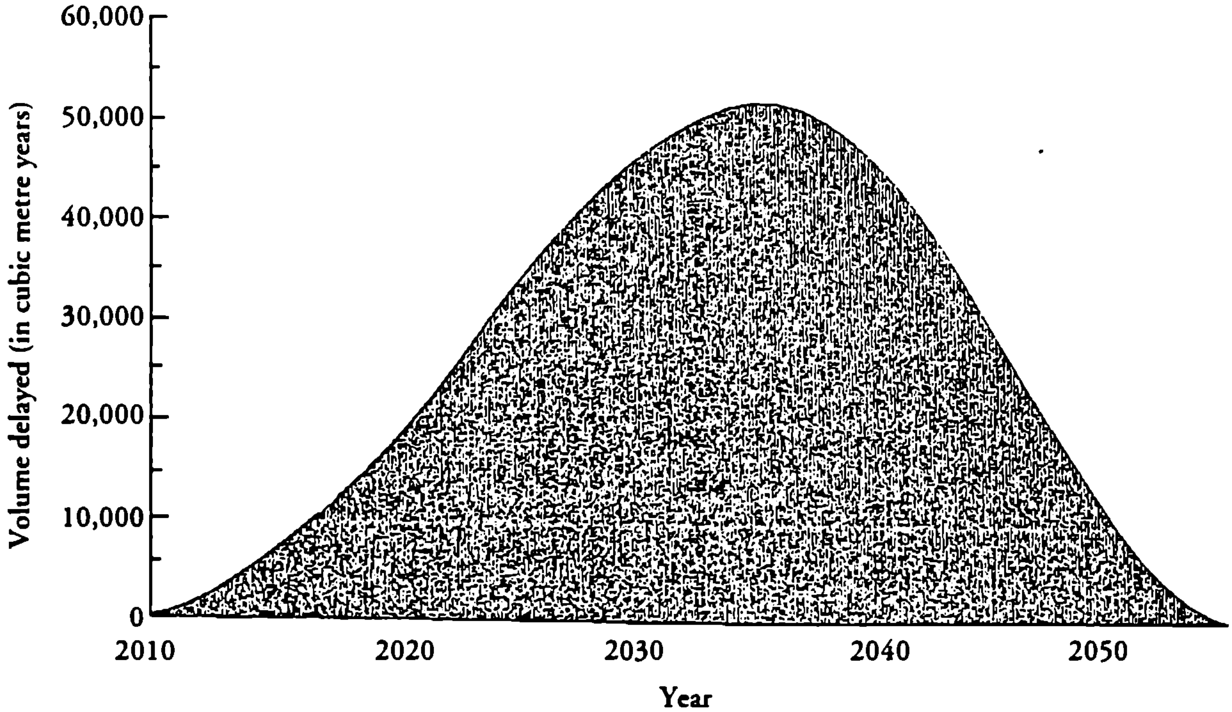


Figure 6 Volume of timber production that would have to be shifted to smooth out forecast production to 16 million $m^3 year^{-1}$

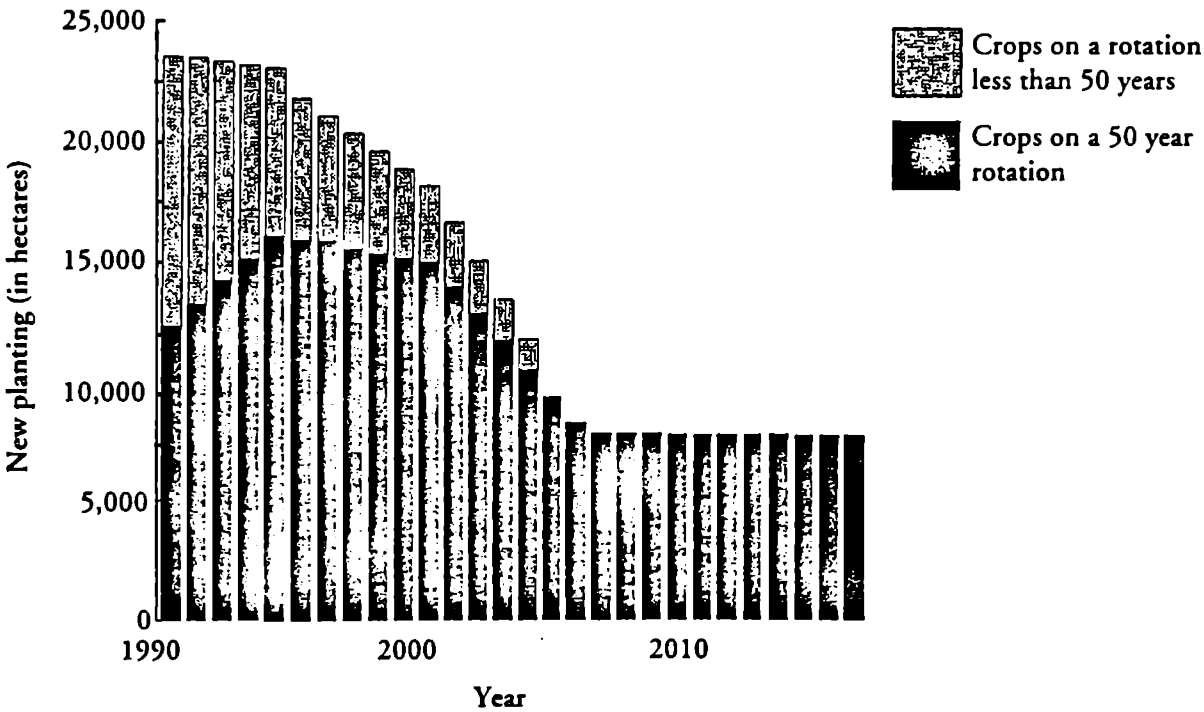


Figure 7 New planting programme that would sustain the current UK production forecast at 20 million m^3 annually after 2025

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'FORESTRY EXPANSION: A STUDY OF TECHNICAL, ECONOMIC AND ECOLOGICAL FACTORS'

This is one of a series of papers which form part of a study to consider the scale, location and nature of forestry expansion in Britain.

The Forestry Commission invited fourteen specialist authors, including economists, foresters, ecologists and biological scientists to write about current knowledge and to assess the main factors bearing on decisions about the future direction of forestry expansion. It is intended that the papers will form the basis for future discussions of the location and type of forestry that will best meet the demands of society for wood products, jobs, recreation, amenity, wildlife conservation, carbon storage and the other uses and public benefits supplied by the country's forests.

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The full list of papers is as follows:

Occasional Paper No	Title	Author
33	Introduction	Professor Ian Cunningham, Macaulay Land Use Research Institute
34	British Forestry in 1990	Hugh Miller, University of Aberdeen
35	International Environmental Impacts: Acid Rain and the Greenhouse Effect	Melvyn Cannell and John Cape, Institute of Terrestrial Ecology
36	The Long Term Global Demand for and Supply of Wood	Mike Arnold, Oxford Forestry Institute
37	UK Demand for and Supply of Wood and Wood Products	Adrian Whiteman, Forestry Commission
38	Development of the British Wood Processing Industries	Iain McNicoll and Peter McGregor, University of Strathclyde and Bill Mutch, Consultant
39	The Demand for Forests for Recreation	John Benson and Ken Willis, University of Newcastle
40	Forests as Wildlife Habitat	John Good, Ian Newton, John Miles. Rob Marrs and John Nicholas Greatorex-Davies, Institute of Terrestrial Ecology
41	Forestry and the Conservation and Enhancement of Landscape	Duncan Campbell and Roddie Fairley, Countryside Commission for Scotland
42	The Impacts on Water Quality and Quantity	Mike Hornung and John Adamson, Institute of Terrestrial Ecology
43	Sporting Recreational Use of Land	James McGilvray and Roger Perman, University of Strathclyde
44	The Agricultural Demand for Land: Its Availability and Cost for Forestry	David Harvey, University of Newcastle
45	Forestry in the Rural Economy	John Strak and Chris Mackel, Consultants
46	New Planting Methods, Costs and Returns	Jim Dewar, Forestry Commission
47	Assessing the Returns to the Economy and to Society from Investments in Forestry	David Pearce, University College London

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